C H A P T E R 4

Stormwater Pollutant Removal Criteria

Introduction

This chapter presents the criteria and methodologies necessary to meet the pollutant removal requirements of the NJDEP's Stormwater Management Rules (NJAC 7:8). According to these Rules, a land development that creates 0.25 acres or more of new or additional impervious surface must include stormwater management measures that reduce the average annual total suspended solids (TSS) load in the development site's post-construction runoff by 80 percent. This 80 percent requirement has been based, in part, upon Section 6217(g) of the 1990 Coastal Zone Management Act Reauthorization Amendments as enforced by the USEPA. In addition, the stormwater management measures at the development site must also reduce the average annual nutrient load in the post-construction runoff by the maximum extent feasible. This requirement has been included in the Stormwater Management Rules because nutrients, consisting primarily of various forms of nitrogen and phosphorous, are recognized as a major class of stormwater pollutants from land development.

The stormwater management measures used to reduce the average annual TSS and nutrient loads can be structural and/or nonstructural in nature. To achieve the reduction requirements, they must be designed to treat the runoff from NJDEP's Stormwater Quality Storm, a 1.25-Inch/2-Hour variable rate rainfall event. Details of the Stormwater Quality Storm are presented in Chapter 5. Details of nonstructural and structural stormwater management measures, also known as Best Management Practices (BMPs), are presented in Chapters 2 and 9, respectively.

TSS Removal Rates for Individual BMPs

As noted above, the NJDEP's Stormwater Management Rules require an 80 percent TSS reduction in the post-construction runoff from a land development site. This is to be achieved by conveying the site's runoff through one or more onsite BMPs that have the ability to remove a portion of the TSS load. To demonstrate compliance with this requirement, the NJDEP has adopted official TSS removal rates for each of the BMPs described in detail in Chapter 9. These BMPs and their adopted TSS removal rates are presented below in Table 4-1. Different removal rates and BMPs may be utilized if supporting information is provided and accepted by the review agency.

It is important to note that the TSS removal rates shown in Table 2-1 have been based upon several sources of BMP research and monitoring data as well as consultation with stormwater management experts. As demonstrated by that research, actual TSS removals at specific BMPs during specific storm events will depend upon a number of site factors and can be highly variable. As such, the TSS removal rates presented in Table 4-1 are considered representative values that are based upon a recognition of both this variability and the State's need to develop and implement a statewide stormwater management program. Furthermore, the rates in the table are also considered to accurately represent the relative TSS removal efficiencies of the various BMPs listed in the table and presented in detail in Chapter 9.

Table 4-1: TSS Removal Rates for Individual BMPs

Best Management Practice (BMP)	Adopted TSS Removal Rate (%)
Bioretention System	90
Constructed Stormwater Wetland	90
Dry Well	Volume Reduction[2]
Extended Detention Basin	40 to 60[1]
Infiltration Basin	80
Manufactured Treatment Device	TBD[3]
Pervious Paving	Volume Reduction[2]
Forested Buffer	70
Sand Filter	80
Vegetated Filter Strip	50
Wet Pond	50-90[4]

[1] Final rate based upon detention time. See Chapter 9.
[2] See text below.
[3] To be determined through testing on a case-by-case basis. See text below.
[4] Final rate based upon permanent pool volume and any detention time. See Chapter 9.

As shown in Table 4-1, neither dry wells nor pervious paving have an adopted TSS removal rate. This is due to the fact that, as described in Chapter 9, both of these BMPs are intended to infiltrate runoff only from areas with minimal TSS loading. As such and despite their ability to infiltrate runoff, neither are considered to be effective in reducing the overall TSS load from a development site. However, in recognition of this infiltration ability, both BMPs can be used to reduce the site runoff volume and, therefore, the size and cost of other onsite BMPs used for TSS removal. Such use of these "volume reduction" BMPs are illustrated in Example 4-2 below and described in detail in Chapter 5.

In addition, Table 4-1 also indicates that the adopted TSS removal rates for manufactured treatment devices must be determined on a case-by-case basis. Manufactured treatment devices are proprietary water quality devices that use a variety of stormwater treatment techniques. They have and continue to be developed by a variety of companies. As such, the actual TSS removal rate for a specific device will depend on a number of factors, and a single representative TSS removal rate cannot be developed. Instead, the NJDEP's Division of Science, Research & Technology (DSRT) is responsible for certifying final pollutant removal rates for all manufactured treatment devices. This certification process is described in detail in Chapter 9.

Finally, as noted in Table 4-1, the adopted TSS removal rates for Extended Detention Basins and Wet Ponds will vary depending on such specific features as detention time and permanent pool volume. Details for each BMP are provided in Chapter 9.

TSS Removal Rates for BMPs in Series

The TSS removal rates specified in Table 4-1 for certain BMPs range as low as 40 percent, which indicates that these BMPs will not be able to meet the 80 percent TSS reduction requirement by themselves. As such, it will be necessary at times to use a series of BMPs in a treatment train to achieve the 80 percent TSS removal rate. In such cases, the total removal rate of the BMP treatment train is based on the removal rate of the secondary BMP applied to the fraction of the TSS load remaining after the runoff has passed through the first BMP.

A simplified equation for the total TSS removal rate (R) for two BMPs in series is:

$$R = A + B - (A \times B) / 100 \qquad \text{(Equation 4-1)}$$

Where:

R = Total TSS Removal Rate

A = TSS Removal Rate of the First or Upstream BMP

B = TSS Removal Rate of the Second or Downstream BMP

The use of this equation is demonstrated in Example 4-1 below.

Example 4-1: Total TSS Removal Rate for BMPs in Series

A stormwater management system consists of both a vegetated filter strip and an extended detention basin to collect and treat runoff from a small commercial parking lot. Runoff from the parking lot will sheet flow off the parking lot through a vegetative filter strip before being discharged to an extended detention basin. The extended detention basin will have a total detention time of 24 hours which, as described in Chapter 5, enables the basin to have the maximum adopted TSS removal rate.

From Table 4-1, the adopted TSS removal rates for the individual BMPs are:

Vegetative Filter Strip = 50%

Extended Detention Basin 60%

From Equation 4-1,

$$R = A + B - (A \times B) / 100$$

$$R = 50 + 60 - (50 \times 60) /100 = 110 - 30 = 80\% \text{ Total TSS Removal Rate}$$

It should be noted that the total TSS removal rate of the stormwater management system described in Example 4-1 above can also be computed by the following technique:

Initial TSS Load Upstream of Vegetated Filter Strip = 1.0
TSS Load Removed by Vegetated Filter Strip = 1.0 X 50% Removal Rate = 0.5
Remaining TSS Load Downstream of Vegetated Filter Strip = 1.0 – 0.5 = 0.5
TSS Load Removed by Extended Detention Basin = 0.5 X 60% Removal Rate = 0.3
Final TSS Load Downstream of Extended Detention Basin = 0.5 – 0.3 = 0.2
Total TSS Removal Rate = 1.0 – 0.2 = 0.8 or 80%

This technique can also be used in place of Equation 4-1 when there are more than two BMPs in series.

Guidelines for Arranging BMPs in Series

As described in Example 4-1, it may be necessary or desirable to use a series of BMPs in a treatment train to provide adequate TSS removal. In selecting the order or arrangement of the individual BMPs, the following general guidelines should be followed:

1. Arrange the BMPs from upstream to downstream in ascending order of TSS removal rate. In this arrangement, the BMP with the lowest TSS removal rate would be located at the upstream end of the treatment train. Subsequent or downstream BMPs should have progressively higher TSS removal rates.
2. Arrange the BMPs from upstream to downstream in ascending order of nutrient removal rate. Similar to 1 above, the BMP with the lowest nutrient removal rate would be located at the upstream end of the treatment train in this arrangement. Subsequent or downstream BMPs should have progressively higher nutrient removal rates.
3. Arrange the BMPs from upstream to downstream by their relative ease of sediment and debris removal. In this arrangement, the BMP from which it is easiest to remove collected sediment and debris would be located at the upstream end of the treatment train. In subsequent or downstream BMPs, it should be progressively more difficult to remove sediment and debris.

It should be noted that, in applying these guidelines, it is recommended that they be generally applied in the order presented above. As such, a series of BMPs would be preliminarily arranged in accordance with their relative TSS removal rates (Guideline 1). This preliminary arrangement would then be refined by the BMPs' relative nutrient removal rate (Guideline 2) and then their ease of sediment and debris removal (Guideline 3). Two or more iterations may be necessary to select the optimum arrangement.

Sites with Multiple Discharge Points and Subareas

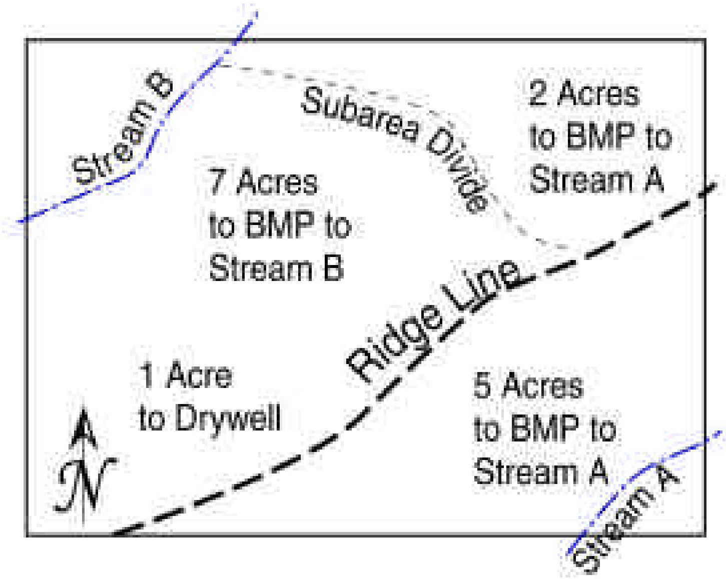
In general, if runoff is discharged from a site at multiple points, the 80 percent TSS removal requirement will have to be applied at each discharge point. However, the application of this requirement will depend upon the exact amount of physical and hydraulic separation between the various discharge points. If the runoff from two or more discharge points combine into a single waterway or conveyance system at the site, these separate discharge points can be considered as a single one for purposes of computing TSS removal.

In addition, where there are multiple onsite subareas to a single discharge point, the removal rates for the subareas can be combined through an arithmetic averaging technique. It must be noted that the averaging of TSS removal rates are applicable only where the anticipated pollutant loadings from each of the various subareas are similar. As such, the TSS removal rate for an onsite BMP receiving runoff from a commercial parking lot cannot be averaged with a second onsite BMP serving a lawn or landscaped area.

Example 4-2 below provides further explanations of the procedures described above for computing overall TSS removal rates at sites with both multiple discharge points and subareas.

Example 4-2: TSS Removal Rates at Sites with Multiple Discharge Points and Subareas

A 15-acre site has a ridge running through it northeast to southwest. Five acres of the site drain in a southwesterly direction to Stream A, while 10 acres drain in a northwesterly direction to Stream B. Since Stream A and B do not join at the site, each portion of the site will have to be evaluated separately for compliance with the 80 percent TSS removal requirement.



Southeast Drainage to Stream A

The site runoff to Stream A will first be routed through a bioretention system.

The bioretention system TSS removal rate is 90 percent. This exceeds the 80 percent removal requirements and meets the TSS removal requirement for the southeast drainage area.

Northwest Drainage to Stream B

One acre of rooftop runoff from the Stormwater Quality Storm will be directed to dry wells, thereby reducing the drainage area to be served by other BMPs by 1 acre. The remaining nine acres to Stream B are divided into two subareas of two and seven acres, respectively. A forested buffer will be considered to treat the runoff from one subarea, while a constructed stormwater wetland will be considered for the other subarea. The anticipated pollutant loadings from each subarea are similar.

The forested buffer TSS removal rate is 70 percent, which is not sufficient by itself to meet the 80 percent TSS removal requirement. However, the constructed stormwater wetland TSS removal rate is 90 percent, which exceeds the 80 percent TSS removal requirement. By averaging of removal rates, the use of these BMPs may be sufficient to meet the 80 percent removal requirement for this portion of the site.

Two alternatives to address the TSS load in the runoff from the northwest portion of the site are presented below.

OPTION A: The forested buffer will be used to treat the runoff from the seven acre subarea, while the constructed stormwater wetland will be used in the two acre subarea.

Apply the various TSS removal rates to the areas to be treated by each BMP and determine the average TSS removal rate for the entire northwest portion of the site.

7 Acres X 70% TSS Removal for Forested Buffer = 4.9

<u>2 Acres X 90% TSS Removal for Wetland = 1.8</u>

Total Acreage-Removal Rate = 6.7

6.7 Total Acreage-Removal Rate / 9 Acres = 0.74 or 74% Average TSS Removal Rate

Therefore, for Option A, the northwest portion of the site does not meet the 80 percent TSS removal requirement.

OPTION B: The forested buffer will be used to treat the runoff from the two acre subarea, while the constructed stormwater wetland will be used in the seven acre subarea.

Once again, apply the various TSS removal rates to the areas to be treated by each BMP and determine the average TSS removal rate for the entire northwest portion of the site.

2 Acres X 70% TSS Removal for Forested Buffer = 1.4

<u>7 Acres X 90% TSS Removal for Wetland = 6.3</u>

Total Acreage-Removal Rate = 7.7

7.7 Total Acreage-Removal Rate / 9 Acres = 0.86 or 86% Average TSS Removal Rate

Therefore, for Option B, the northwest portion of the site does meet the 80 percent TSS removal requirement.

Nutrients

In addition to TSS removal, the NJDEP's Stormwater Management Rules also require the reduction of post-construction nutrients to the maximum extent feasible. In general, to demonstrate compliance with this requirement, a two step approach should be used. First, the input of nutrients to the drainage area should be limited as much as feasible. Second, when selecting a stormwater management measure to address the TSS removal requirement, the measure with the best nutrient removal rate that also best meets the site's constraints should be chosen. Details of each step in this approach are provided below.

Reducing Nutrient Input

A significant amount of nutrients are in stormwater runoff due to fertilization of lawns. As described in Chapter 2, lawns should be minimized in favor of other vegetated cover. Existing site areas with desirable vegetation communities should be left in a natural state and forested areas and meadows should be considered as alternatives to the standard lawn. Ground covers provide aesthetically pleasing, innovative landscapes that are adaptable to the local environment. These types of land cover reduce lawn area and the consequent need for fertilization. A landscape design that minimizes the use of lawn can be beneficial in preventing nutrients from fertilizers as well as pesticides from stormwater runoff.

Soil testing determines the soil nutrient level as well as pH. Using the test results to determine the appropriate application of lime and fertilizer required for lawn areas will increase efficient uptake and decrease associated costs of lawn maintenance as well as minimizing nutrient input. Low or no phosphorous fertilizers may be adequate to maintain the health of the landscape after the vegetation has fully established. Soil test kits are available at most lawn and garden care centers as well as through the Rutgers Cooperative Extension county offices. Fertilization specifications must be included in the Operation and Maintenance Manual.

Pet waste is another source of nutrients in stormwater runoff. To prevent or minimize pet waste problems, residents must be required to pick up after their animal and dispose of the material in the toilet or garbage. Homeowner associations must include this condition in homeowner's agreements. Signage should be located strategically throughout the development to reinforce this criterion. Education is critical to successful pet waste management.

Nutrient Removal Rates

Site constraints and the requirement to reduce the post-construction TSS load play a significant part in the selection of an appropriate BMP for a development site. However, the effectiveness of nutrient removal must also be considered in the final selection of the BMP. The chosen BMP must meet the TSS criteria, but must also maximize nutrient removal for the site. To assist with the selection of BMPs for nutrients, information regarding estimated nutrient removal rates is provided in Table 2.

Table 4-2: Estimated Pollutant Removal Rates for Total Phosphorous and Nitrate Nitrogen

Best Management Practice	Total Phosphorous (%)	Nitrate Nitrogen(%)
Bioretention Basin	60	Insufficient Data
Bioretention Swale	30	50
Constructed Stormwater Wetland	40	60
Extended Detention Basin	30	0
Infiltration Structure w/ Filter Strip	60	25
Manufactured Treatment Devices	TBD	TBD
Forested Buffer	50	80
Surface Sand Filter	50	Negative
Perimeter Sand Filter	60	Negative
Vegetative Filter Strip	20	10
Wet Pond	50	30

Adapted from: Claytor & Schueler, 1996; Schueler, 1992 and 1997

NOTES: Pollutant concentration reduction percentages are derived from research data and professional judgment. If the actual inflow pollutant concentration is lower than that of the research condition, reduction percentages will be less. If the pollutant is present at a very low, irreducible concentration, the reduction will be zero. Conversely, if the actual pollutant concentration is significantly higher than the research study, the percent reduction should be greater. Practices listed may be newly installed or retrofits of existing stormwater management facilities.

BMPs are intended to reduce the pollutants in stormwater runoff. However, sometimes an unintended consequence of stormwater management facilities is their attractiveness to waterfowl, such as Canada geese. Canada geese are attracted to lawn areas adjacent to water. Wet ponds and other stormwater management structures can appeal to these waterfowl. Their resulting fecal input results in an input of nutrients in a system that was designed to reduce pollutants, such as nutrients. Adjustments must be made to the design and/or maintenance plan to discourage waterfowl from contributing pollutants to the stormwater measure. Additional guidance on Canada Geese is available in *Management of Canada Geese in Suburban Areas: A Guide to the Basics*, available at http://www.state.nj.us/dep/watershedmgt/DOCS/BMP_DOCS/Goosedraft.pdf.